Claims

1. A rapidly responding, false detection immune smoke detector of a light obscuration type, comprising:

a light source from which a light beam propagates;

a light detector having a light receiving surface with a light detecting area and producing a signal in response to light incident on the light receiving surface; and

a light reflective imaging assembly in optical association with the light source and the light detector, the imaging assembly including first and second spaced-apart optical components having respective first and second opposed light reflecting surfaces forming between them a spatial region that smoke particles can occupy, the first and second optical components having light directing properties that cooperate to reflect the light beam between the first and second light reflecting surfaces and to direct the light beam toward the light detector for incidence on its light receiving surface, and the first and second optical components controlling the light beam by providing it with a beam width that is sufficiently wide to render insignificant contributions of anomalous light reflections but that converges to illuminate the light receiving surface within the confines of the light detecting area and thereby cause the light detector to produce a signal corresponding to a concentration of the smoke particles occupying the spatial region.

2. The smoke detector of claim 1, further comprising a rate of change measurement detector operatively associated with the light detector to measure a rate of change of the concentration of smoke particles occupying the spatial region, the rate of change measurement detector responding to the signal produced by the light detector to determine an elapsed time between changes in concentrations of smoke particles between first and second smoke concentration threshold levels.

3. The smoke detector of claim 2, in which the first smoke concentration threshold level is less than the second smoke concentration threshold level and the rate of change measurement detector produces a signal indicating that a rate of rise of the concentration of smoke particles from the first smoke concentration threshold level to the second smoke concentration threshold level has exceeded a first predetermined threshold rate and the concentration of smoke particles persists above the second smoke concentration threshold level for a predetermined time.

4. The smoke detector of claim 3, further comprising an alarm threshold circuit to which an alarm smoke concentration threshold level is set, and in which the

first smoke concentration threshold level is less than the alarm smoke concentration threshold level.

5. The smoke detector of claim 2, in which the first smoke concentration threshold level is less than the second smoke concentration threshold level and the rate of change measurement detector produces a signal indicating that a rate of rise of the concentration of smoke particles from the first smoke concentration threshold level to the second smoke concentration threshold level is less than a second predetermined threshold rate to indicate a long-term degradation of intensity of light incident on the light receiving surface of the light detector.

6. The smoke detector of claim 1, in which the light directing properties of the first and second optical components cooperate to reflect the light beam multiple times between the first and second light reflecting surfaces to establish a smoke detection sensitivity for the smoke detector.

7. The smoke detector of claim 1, in which one of the first and second light reflecting surfaces includes a pair of openings, the light beam emitted by the light source propagating through one of the pair of openings and the light beam received by the light detector after incidence on the first and second light reflecting surfaces propagating through the other one of the pair of openings.

8. The smoke detector of claim 7, in which an optical axis extends between the first and second light reflecting surfaces and in which the openings included in the pair are positioned on opposite sides of the optical axis.

9. The smoke detector of claim 1, in which the opposed first and second light reflecting surfaces have surface normals and in which the first and second light reflecting surfaces are positioned so that their surface normals are parallel to each other.

10. The smoke detector of claim 1, in which the first light reflecting surface is curved, the first optical component has an opposite surface, and the light source and the light detector are positioned in proximity to the opposite surface of the first optical component.

11. The smoke detector of claim 1, in which the first and second light reflecting surfaces are curved.

12. The smoke detector of claim 11, in which each of the first and second optical components has an opposite surface, and one of the opposite surfaces is positioned in proximity to the light source and the light detector.

13. The smoke detector of claim 1, in which one of the first and second light reflecting surfaces is in the form of a concave optical surface and the other of the first and second light reflecting surfaces is in the form of a plano optical surface.

14. The smoke detector of claim 13, in which the concave optical surface is of spherical shape with a surface normal at an apex, the spherical optical surface being positioned so that its surface normal is normal to the plano optical surface.

15. The smoke detector of claim 13, in which the first and second light reflecting surfaces are spaced apart by a distance to define a path length, and in which the concave optical surface has a focal length that is about twice the path length and an effective beam length that is about six times the path length.

16. The smoke detector of claim 1, in which an optical axis extends between the first and second light reflecting surfaces and in which, for at least one of the first and second light reflecting surfaces, the multiple reflections undergone by the light beam take place on both sides of the optical axis.

17. The smoke detector of claim 1, in which the light beam reflects off at least one of the first and second reflecting surfaces multiple times before the light beam is incident on the light detector.

18. The smoke detector of claim 1, in which the light source includes a light-emitting diode.

19. The smoke detector of claim 18, in which the light-emitting diode emits light having a wavelength of less than about 800 nm.

20. The smoke detector of claim 1, in which the light beam is within a wavelength range of between about 350 nm and about 470 nm.

21. The smoke detector of claim 1, in which the light reflective imaging assembly is in the form of an integral unit.

22. A rapidly responding, false detection immune smoke detector of a light obscuration type, comprising:

a light reflective imaging assembly including a pair of spaced-apart, opposed light reflecting surfaces between which a concentration of smoke particles can enter;

a light source from which a light beam propagates in a direction for reflection by the light reflecting surfaces, the light beam reflecting off each one of the pair of light reflecting surfaces as it propagates through the light reflective imaging assembly, the light beam exiting the light reflective imaging assembly having an

intensity corresponding to the concentration of smoke particles present between the light reflecting surfaces; and

a light detector positioned to receive a light beam representing the concentration of smoke particles in the light reflective imaging assembly.

23. The smoke detector of claim 22, further comprising:

a light source modulator providing to the light source a sampling sequence of pulses that cause intermittent propagation of the light beam, the sampling sequence including an ON interval during which a first group of pulses causes the light beam to propagate and an OFF interval during which the light beam does not propagate;

the detector receiving the light beam representing the concentration of smoke particles and producing an ON state output signal during the ON interval and an OFF state output signal during the OFF interval, the ON state and OFF state output signals having a common background noise signal component; and

a signal conditioner receiving the ON state and OFF state output signals and removing the common background noise signal component to produce a noise-corrected signal value representing the concentration of smoke particles present between the light reflecting surfaces during the sampling sequence.

24. The smoke detector of claim 23, in which the signal conditioner removes the common background noise signal component by computing average ON state output signal values and average OFF state output signal values and subtracting them to produce the noise-corrected signal value.

25. A false detection immune, light obscuration type smoke detector that is capable of detecting particles of different sizes, comprising:

a light reflective imaging assembly including a pair of spaced-apart, opposed light reflecting surfaces between which gas-borne particles can enter;

first and second light sources from which respective first and second light beams of different wavelengths propagate in directions for reflection by the light reflecting surfaces, the first and second light beams reflecting off each one of the pair of light reflecting surfaces as the first and second light beams propagate through the light reflective imaging assembly, the first and second light beams exiting the light reflective imaging assembly having intensities corresponding to concentrations of gas-borne particles of different ranges of sizes present between the light reflecting surfaces, the first and second ranges of sizes being determined by the wavelengths of, respectively, the first and second light beams; and

a light detector positioned to receive a light beam representing at least one of the first and second ranges of sizes of the gas-borne particles in the light reflective imaging assembly.

26. The smoke detector of claim 25, further comprising pulse circuitry operatively associated with the first and second light sources to produce for reception by the light detector the light beam carrying noncoincident representations of the first and second ranges of sizes of the gas-borne particles.

27. The smoke detector of claim 25, in which the wavelength of the first light beam is less than about 500 nm.

28. The smoke detector of claim 27, in which the wavelength of the second light beam is greater than about 800 nm.

29. The smoke detector of claim 25, in which the first and second wavelengths are, respectively, less than about 500 nm and greater than about 800 nm, in which the light detector constitutes a first light detector, and in which the light beam constitutes a first measurement light beam representing the first range of sizes of gas-borne particles, so that the first light detector receives the first measurement light beam, and further comprising:

a second light detector that receives a second measurement light beam representing the second range of sizes of gas-borne particles; and

a discriminator that receives signals produced by the first and second light detectors and corresponding to the respective first and second measurement light beams, the discriminator determining average sizes of the gas-borne particles present between the light reflecting surfaces and thereby distinguishing the gas-borne particles from one another by their origins as indicated by their sizes.

30. A smoke detector of an obscuration type configured for placement of its optical components within the interior of an air duct having a duct side wall with an exterior surface, the smoke detector monitoring the quality of air flowing in an air flow direction through the interior of the air duct, comprising:

a light reflective imaging assembly including a pair of spaced-apart, opposed light reflecting surfaces between which a concentration of smoke particles can enter and an optical axis extends;

a support configured to extend through an opening in the duct side wall and having first and second ends, the first end holding the light reflective assembly within the interior of the air duct in a desired orientation that positions the optical axis

transversely of the direction of air flow within the air duct, and the second end being mechanically coupled to the side wall to secure the support and thereby set the light reflective assembly in the desired orientation;

a light source from which a light beam propagates in a direction for reflection by the light reflecting surfaces, the light beam reflecting off each one of the pair of light reflecting surfaces as it propagates through the light reflective imaging assembly, the light beam exiting the light reflective imaging assembly having an intensity corresponding to the concentration of smoke particles present between the light reflecting surfaces; and

a light detector positioned to receive a light beam representing the concentration of smoke particles in the light reflective imaging assembly.

31. The smoke detector of claim 30, in which the light source and the light detector are mounted within the interior of the air duct and adjacent the light reflective imaging assembly.

32. The smoke detector of claim 30, further comprising an alarm control circuit contained in a temperature resistant housing that is coupled to the second end of the support and mounted with a temperature resistant seal on the exterior surface of the duct side wall.

33. The smoke detector of claim 30, in which the support includes a tubular arm that extends through the opening in the duct side wall and into the interior of the air duct.

34. The smoke detector of claim 33, further comprising an alarm control circuit that is coupled to the second end of the support, in which the light detector is held in position by the support and within the interior of the air duct, and in which the tubular arm provides a conduit for a communication link between the light detector and the alarm control circuit.

35. A rapidly responding, false detection immune smoke detector of a light obscuration type, comprising:

a light source from which a light beam propagates;

a light detector having a light receiving surface with a light detecting area and producing a signal in response to light incident on the light receiving surface;

a light reflective imaging assembly in optical association with the light source and the light detector, the imaging assembly including first and second spaced-apart optical components having respective first and second opposed light reflecting

surfaces forming between them a spatial region that smoke particles can occupy, the first and second optical components having light directing properties that cooperate to reflect the light beam between the first and second light reflecting surfaces and to direct the light beam toward the light detector for incidence on its light receiving surface and thereby cause the light detector to produce a signal corresponding to a concentration of the smoke particles occupying the spatial region; and

circuitry operatively associated with the light detector to acquire during a data gathering time interval data from the signal corresponding to the concentration of the smoke particles occupying the spatial region, the data gathering time interval being long as compared to the time of a slow fire, and the circuit determining an adjustment value for application to the signal produced by the light detector in response to a change in the acquired data that, in the absence of smoke, is greater than a preassigned operational tolerance after the data gathering time interval.